

Amendment
U.S. Patent Application No. 10/019,474

REMARKS

Claims 1-4, 11 and 44-79 are pending in the subject application and have been examined. Claims 1-4, 11, 44-71 and 74-79 stand rejected. Applicant acknowledges and appreciates the Examiner's indication that claims 72 and 73 would be allowable if rewritten to include all of the limitations of the base claim and any intervening claims. Claims 58 and 59 have been amended in the present Amendment, and support for the amended claims can be found throughout the specification. Favorable reconsideration of the application and allowance of all of the pending claims are respectfully requested in view of the above amendments and the following remarks.

The Examiner has indicated that the declaration is defective because of an improper claim of foreign priority to a PCT application. A new declaration executed by the inventors is submitted herewith that is in compliance with 37 CFR 1.67(a). Accordingly, the Examiner is requested to withdraw this objection.

Claims 1-4, 11 and 44-57 stand rejected under 35 U.S.C. §102(e), as being anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over U.S. Patent No. 6,389,820 to Rogers et al. Claims 58, 61-71, 77 and 78 stand rejected under 35 U.S.C. §103(a) as obvious over Rogers et al., and claims 74-76 under 35 U.S.C. §103(a) as obvious over Rogers et al. in view of U.S. Patent No. 2,270,016 to Benesh. Further, claims 59, 60 and 79 stand rejected under 35 U.S.C. §103(a) as obvious over Rogers et al. in view of U.S. Patent No. 5,536,893 to Gudmundsson. Applicant respectfully traverses these rejections in view of the following remarks.

Independent claim 1 recites a natural gas hydrate characterized by a gas content in excess of $180 \text{ Sm}^3 \text{ per m}^3$. Independent claim 11 recites a natural gas hydrate characterised by a hydrate desolution temperature in excess of approximately -1°C at approximately atmospheric pressure. It is respectively submitted that Rogers et al. does not disclose or suggest the recited features of these claims.

Rogers et al. discloses the formation of a hydrate composition such as a natural gas hydrate. In particular, Rogers et al. identifies one problem associated with forming a hydrate composition is that free water (i.e., water not bound in hydrate form) becomes entrapped

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between hydrate particles, resulting in an appreciable volume of storage space being occupied by the entrapped interstitial water and more water being trapped between the solid hydrate particles than is bound in the hydrate structure (e.g., see Col. 2, lines 20 to 35 of Rogers et al.). Another problem identified by Rogers et al. is that the formation of hydrates in a quiescent system is extremely slow at hydrate-forming temperatures and pressures (e.g., see Col. 1, lines 58-66 of Rogers et al.).

Rogers et al. further describes that these problems are overcome by adding a surfactant to a quiescent gas-water system. The result is that, instead of forming discrete hydrate particles, a cylindrical mass of hydrate builds-up on the surfactant-wetted walls of the cell (e.g., see Col. 6, lines 9-64 of Rogers et al.). The boost in gas solubility is described in Rogers et al. as being directly attributed to the particular way in which the hydrate particles form on the walls, due to an increase in the rate of hydrate formation when the surfactant is present. The presence of surfactant maximizes the gas content of the packed hydrate particles, as entrapped free water between packed particles continues to form hydrates after adsorption onto the cell walls until complete utilization of entrapped water is approached (see Col. 6, lines 25-30 of Rogers et al.).

There is simply no disclosure or suggestion in Rogers et al. that a natural gas hydrate is obtained with a gas content in excess of $180 \text{ Sm}^3 \text{ per m}^3$ or with a hydrate desolution temperature in excess of approximately -1°C at approximately atmospheric pressure as recited in claims 1 and 11. However, the Examiner asserts that such features would necessarily exist in the hydrates formed in Rogers et al., because Rogers et al. discloses that the utilization of water in the hydrates can approach 100% and that the gas content of the hydrate is maximized. This rationale is a misinterpretation of the disclosure of Rogers et al.

As noted above, Rogers is concerned with using a surfactant to reduce the amount of interstitial water between hydrate particles being formed so as to obtain a solid hydrate mass having a high bulk density, where “the conversion of interstitial water into hydrate particles enhances the prospects of utilizing hydrates for gas storage because the solid hydrate particle mass contains minimal amounts of unreacted free water” (Col. 6, lines 32 to 36 of Rogers et al.). Contrary to the Examiner’s rationale, this does not necessarily mean that the gas content within

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each hydrate particle formed, or the desolution temperature of the formed hydrate particles for that matter, has increased to the recited values of claims 1 and 11. At best, Rogers et al. refers to the gas content being maximized in a volume including the packed hydrate particles and interstitial spaces between the particles in which free water is present and not the maximizing of gas content within each hydrate particle formed. Accordingly, claims 1 and 11 are not anticipated by Rogers et al., and the Examiner is requested to withdraw this rejection.

Regarding the rejection of claims 1 and 11 as being obvious in view of Rogers et al., it is respectfully submitted that the Examiner has not met the prima facie burden for showing obviousness as set forth in MPEP § 706.02(j). In particular, the Examiner must provide a proposed modification to the applied reference necessary to arrive at the claimed subject matter (i.e., the recited gas content and desolution temperature of claims 1 and 11), and an explanation why one of ordinary skill in the art at the time the invention was made would have been motivated to make the proposed modification.

The only reasoning provided by the Examiner is that the claimed gas content and desolution temperature cited in claims 1 and 11 would obviously have been present. This argument appears to be one of anticipation, where there is an assertion that these features would necessarily or inherently be present. Applicant's traversal and response to this rationale has already been addressed above. If the Examiner is indicating the recited features are obvious, then there must be some indication that, while Rogers et al. does not anticipate these features, one skilled in the art would be motivated to modify Rogers et al. to obtain such features based upon some reasonable rationale. The Examiner has provided no motivation as to how Rogers et al. could be reasonably modified to obtain the recited features. Accordingly, the Examiner has not met the initial burden showing that claims 1 and 11 are obvious in view of Rogers et al., and the Examiner is requested to withdraw this rejection.

Claims 2-4 and 44-57 each depend, directly or indirectly from claims 1 or 11. Accordingly, these claims should also be allowed based at least upon the previous remarks.

Independent claim 58 recites a method for the production of a natural gas hydrate including the following steps: pre-mixing natural gas and water and an agent adapted to reduce

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the natural gas-water interfacial tension to form a natural-gas water-agent system, allowing the natural gas-water-agent system to reach equilibrium at elevated pressure and ambient temperature, and, after the natural gas-water-agent system has reached equilibrium at elevated pressure and ambient temperature, reducing the temperature of the natural gas-water-agent system to initiate the formation of the natural gas hydrate. There is no disclosure or suggestion of these combined features in Rogers et al.

The Examiner acknowledges that Rogers et al. is silent with regard to the gas-water-surfactant system reaching equilibrium as recited in claim 58. However, the Examiner asserts that it would have been obvious to allow the system to reach equilibrium because hydrate production would be expected as long as the final conditions are effective for the production of hydrates. Applicant respectfully disagrees with this assertion.

In the process of Rogers et al. (e.g., see Col. 5, lines 38-51 of Rogers et al.), water and surfactant are mixed and introduced into a vessel, with the gas being pumped in thereafter. The water-surfactant-gas mixture must be quiescent before the temperature is lowered. When the water and surfactant are introduced into the vessel, this mixture accumulates towards a lowermost end of the vessel. The gas that is introduced into the vessel effectively comes into contact with only the surface of this volume of water and surfactant apart from an amount of the gas that penetrates into the volume of water and surfactant by diffusion. Long after the water-surfactant mixture has achieved quiescence, there would exist a gradient throughout the water-surfactant volume where the amount of gas in contact with the water-surfactant mixture towards the top of the vessel would be greater than that amount of gas in contact with the water-surfactant mixture towards the bottom of the vessel. Even if the gas was pumped in under a very high pressure, it would take an excessive amount of time for equilibrium to be achieved using the process as described in Rogers et al.

In contrast, the recited process of claim 58 includes pre-mixing natural gas and water with the agent adapted to reduce interfacial tension to form a natural gas water agent system. This process step facilitates relatively quick equilibrium of the system. Equilibrium is achieved quickly in part due to the effects of agitation during the pre-mixing stage. The achievement of

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equilibrium can be further accelerated by atomising the pre-mixed natural gas water agent system as it is introduced into the vessel prior to the temperature of the natural gas water system being reduced to initiate the formation of the natural gas hydrate. This results in intimate mixing of the gas-water surfactant.

Moreover, atomising produces very small free droplets of the premixed water-gas-agent system. These very small droplets have a high surface area that allows very high accessibility of the gas to the water molecules to achieve equilibrium. This effect is further enhanced by the presence of the agent that reduces the interfacial tension of each small droplet. It is further understood that the agent adapted to reduce interfacial tension assists in allowing easier entry of the gas into individual water droplets, which is also understood to help increase the gas content of natural gas hydrates formed using this process.

The quiescent conditions of Rogers et al. are fundamentally different to the process as recited in claim 58 that includes the pre-mixing of gas, water and agent to achieve equilibrium conditions. As noted above, the process of Rogers et al., which pumps the gas into the reaction vessel or cell after the addition of a water-surfactant solution into the cell, would have to be operated under suitable pressure conditions and for excessive periods of time to achieve equilibrium of the gas-water-surfactant mixture throughout the reaction vessel. Thus, one would not be motivated to achieve equilibrium conditions in the Rogers et al. process, because achieving such conditions would result in an excessive increase in processing time. In addition, achieving equilibrium in the Rogers et al. process appears to be contrary to one of its intended purposes, namely the increase in hydrate formation rate (and thus a decrease in processing time). Therefore, claim 58 is not obvious in view of Rogers et al., and the Examiner is requested to withdraw this rejection.

Claims 59-79 each depend, directly or indirectly from claim 58. Accordingly, these claims should also be allowed based at least upon the previous remarks.

In addition, claim 77 recites the feature that the pressure exceeds about 50 bars. The Examiner asserts that, while such pressures are not disclosed in Rogers et al., these operating conditions would have been obvious because Rogers et al. discloses that operating conditions

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will vary according to the particular gas-water-surfactant system and one having ordinary skill in the art would adjust the operating conditions in order to obtain maximum efficiency in the process. Applicant respectfully disagrees. Rogers et al. clearly discloses that, while operating conditions may vary, the operating pressure is generally below about 700 psi (about 48 bars). Further, while the operating pressures vary in each of the examples of Rogers et al., these operating pressures are all well below 700 psi. There is simply no motivation, absent reliance upon Applicant's own teachings, to suggest operating at elevated pressures above 50 bars based upon the disclosure of Rogers et al. Therefore, claim 77 should be allowed over Rogers et al. in light of the previous remarks as well as the additional limitations of this claim.

Regarding the rejection of claims 59, 60 and 79 over Rogers et al. in view of Gudmundsson, the Examiner acknowledges that Rogers et al. does not disclose atomizing, agitating or mixing of components. However, the Examiner asserts that it would have been obvious to modify Rogers et al. in view of the teachings of Gudmundsson by atomizing or mixing the components because hydrate formation rates would be improved. Applicant disagrees with assertion and submits that it is unreasonable to combine the process of Gudmundsson with the process of Rogers et al. in an attempt to assert that these claims are obvious.

Gudmundsson describes a method for the production of stable natural gas hydrates for storage. Purified natural gas is delivered to a reactor vessel, and then water is dispersed as thoroughly as possible in the gas bulk phase in the form of fine droplets to form the gas hydrate (see Col. 6, lines 14-64 of Gudmundsson). In contrast, Rogers et al. teaches the addition of water-surfactant solution to the reaction vessel or cell, followed by the injection of gas into the cell (see Col. 5, lines 38-45 of Rogers et al.), so as to form a quiescent water-surfactant-gas system prior to reducing the temperature to form gas hydrates. As discussed above, the whole focus of Rogers et al. is on the way in which the hydrates are caused to form a stable concentric cylinder of solid hydrates that grows rapidly inward from the cell walls. Clearly, the process of Rogers et al. differs significantly from the process of Gudmundsson in the way in which the natural gas is combined with the water solution to form the gas hydrate.

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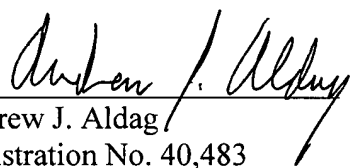
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Moreover, the use of the surfactant in Rogers et al. is described as beneficial in part because it eliminates the need for moving parts and other means of artificial motion during hydrate formation (see Col. 5, lines 56-58 of Rogers et al.). Thus, Rogers et al. appears to teach away from the use of mixing of the components (as recited in claim 79) during hydrate formation. Therefore, claims 59, 60 and 79 should be allowed over Rogers et al. in light of the previous remarks as well as the additional limitations of these claims.

In view of the foregoing, the Examiner is respectfully requested to find the application to be in condition for allowance with claims 1-4, 11 and 44-79. However, if for any reason the Examiner feels that the application is not now in condition for allowance, the Examiner is respectfully requested to call the undersigned attorney to discuss any unresolved issues and to expedite the disposition of the application.

Filed concurrently herewith is a petition for a two month extension of time to respond to the outstanding Office Action, including payment of the petition fee. Applicant hereby petitions for any additional extension of time which may be required to maintain the pendency of this case, and any required fee for such extension is to be charged to Deposit Account No. 05-0460.

Respectfully submitted,


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